COMBINED HEAT AND POWER (CHP) BASELINE ASSESSMENT

Final Report

Prepared For:

New York State Energy Research and Development Authority (NYSERDA)
Albany, NY

Tracey DeSimone, NYSERDA Project Manager

Prepared By:

Industrial Economics, Incorporated (IEc)
Cambridge, Massachusetts

Cynthia Manson, Project Manager

NYSERDA Contract 32883 April 2017

Notice

This report was prepared by Industrial Economics, Inc. (IEc) in the course of performing work contracted for and sponsored by the New York State Energy Research and Development Authority (hereinafter the "Sponsor"). The opinions expressed in this report do not necessarily reflect those of the Sponsors or the State of New York, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, the Sponsors, the State of New York, and the contractor make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, disclosed, or referred to in this report. The Sponsor, the State of New York, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information constrained, described, disclosed, or referred to in this report.

Table of Contents

List of Tables

List of Figures

1. Introduction

1A. Program Description

NYSERDA's Combined Heat and Power (CHP) program seeks to advance the modular CHP market by reducing soft costs and development time and increasing the penetration of CHP. Major program activities focus on providing cost-shared incentives to support the installation of CHP equipment at eligible host site locations. Additionally, and to a lesser extent, the program provides cost-shared incentives to support site-specific feasibility studies. NYSERDA has procured a variety of technical outreach services to raise awareness of the opportunity for CHP among good-prospect candidate sites.

NYSERDA's CHP market transformation efforts include several strategies, including technical assistance for customers during the screening phase, demonstrating the value proposition of CHP recommissioning, providing replication support, and conducting market research into opportunities to reduce costs. Further, NYSERDA's Program Opportunity Notice (PON) 2568 supports the adoption of commercially-mature CHP products through financial incentives for the installation of grid-connected CHP systems. PON 2568 also establishes a catalog of CHP systems ("the Catalog") supplied by pre-approved vendors. These systems are referred to as modular systems, defined as "standardized, pre-packaged systems that are not customized for specific projects," ranging up to 3 MW in size.

1B. Summary of Objectives and Methods

To monitor progress towards the CHP program's intended outcomes, NYSERDA intends to conduct a longitudinal market evaluation to assess the penetration rate of CHP and track changes in other key market conditions. At NYSERDA's request, Industrial Economics, Inc. (IEc) has undertaken an assessment of baseline market penetration and soft costs of CHP systems as a first step in that effort. This assessment is coupled with a summary market characterization assessment (MCA) in that it presents limited information about the size and structure of the market for CHP installation, but data collection focused on the development of an initial installation and cost baseline against which to measure future market changes. The assessment documents the penetration rate of CHP within defined target markets; the number and size of vendors active in New York State and the degree of concentration in the market; and characterization and quantification of soft costs.

The research objectives for this effort are as follows:

1. Determine the current penetration rate of CHP systems within defined target markets, including multifamily residential buildings, educational institutions, hotels, hospitals, offices, assisted living facilities, and restaurants.
2. Determine the number of vendors (and installers) active in New York State, their revenues, number, size, and cost of projects, and the degree of concentration in the market.
3. Characterize soft costs, including whether each category of soft costs is incurred consistently or inconsistently (i.e., only incurred by certain firms and/or in certain types of projects), and whether vendors and installers employ consistent definitions for each category of soft costs;
4. Quantify soft costs, including total (aggregate) soft costs, and costs associated with the permitting and approval process specifically. This study also provides some additional quantitative data regarding how much each category of soft costs contributes to total costs.
5. Explore access to financing during the purchase/sale of a building, and whether the cadence at which the real estate transaction occurs enables or prohibits bundling the financing of CHP into that larger transaction.

Our methods for this effort relied on a central primary data collection effort using a web-based survey tool to collect direct cost information from CHP installers, coupled with an extensive validation effort, including:

1. A review of existing program information, including prior studies of CHP markets in New York State and data from the current NYSERDA CHP program, and general information about CHP markets and technologies. Sources consulted are listed in Appendix B.
2. A web-based survey of CHP vendors active in New York State in 2015. APPRISE conducted this survey in January 2017. IEc conducted follow-up interviews by phone with survey respondents to clarify certain responses and gather additional information. The survey instrument is reproduced in Appendix C.
3. A limited number of interviews with other key market participants.
4. A review of existing studies and data sources to validate survey responses and to build quantitative data on CHP soft cost categories, penetration rates, and overall system costs, including:
    a. A 2016 study conducted by the U.S. Department of Energy and a 2002 study conducted by Energy Nexus Group and Onsite Energy Corporation for NYSERDA, estimating the technical potential for CHP in New York State.
    b. NYSERDA's DG – IDS database and the U.S. DOE CHP database, which provide information on CHP systems installed in New York State.
    c. Commissioning reports submitted to NYSERDA for CHP systems completed in New York State in 2016. As we understand, the reports provided to IEc include all systems completed in 2016 for which NYSERDA is providing financial incentives. We also reviewed a limited number of commissioning reports from 2014 and 2015.

1C. Key Limitations

The total number of CHP vendors and installers active in New York State in 2015 (the baseline timeframe for our study) is too small to support extensive quantitative analysis without conducting a census. While our survey did not reach all active vendors, we believe that survey respondents do provide a sufficient basis to characterize the population as a whole. In particular, respondents represent three of four vendors with systems in NYSERDA's DG-IDS database with systems installed in 2015, accounting for 74 percent of vendors' installed capacity.[1] Respondents also include six out of 11 vendors with CHP systems listed in the NYSERDA CHP Catalog as of May 2016, and four out of five vendors identified by ERS, NYSERDA's contractor for CHP outreach, as being active in the New York City market.

Even so, it is important to note that our results are influenced by the small sample size. Furthermore, not all vendors responded to all survey questions. Our discussion of results highlights data points potentially affected by the small sample size. In particular, relatively few vendors provided revenue data, which limited our ability to collect survey data not only on revenues, but also on average system cost (although we do have cost information from commissioning reports). Similarly, few vendors answered questions on permitting costs and indicated that this is because the facility owner, and not the vendor, incurs these costs.

Another limitation concerns our calculation of the penetration rate by target market. We have used data from the U.S. DOE database of CHP installations to determine the number and capacity of CHP systems

[1] In addition to these four vendors, two non-vendor installers had CHP systems in NYSERDA's DG-IDS database for which monitoring began in 2015. Including those installers, our sample represents three out of six entities and 37 percent of installed capacity listed in DG-IDS for 2015.

installed in New York State.[2] While this appears to be the best data source available, we did not validate it, and it may understate the CHP penetration rate in New York State if CHP installation data are incomplete.

The ownership structure (franchise territories, etc.) of fast-casual restaurants (which serve food on ceramic plates and use large quantities of DHW for washing pots and pans and plates), and the applicability of newly-available micro-CHP systems (e.g., smaller than the 50 kW lower-limit threshold assessed in both the USDOE and the NYSERDA market potential studies), is an emerging market of interest to NYSERDA but because the technology is emerging and the market is new, the baseline data collected for this study does not include any projects of this size or in this sector.

Finally, the Clean Energy Fund Investment Plan for CHP includes a program emphasis on improving the timing and effectiveness of the CHP system sales process, including the number of "prospects" that become aware of the value of CHP, the conversion rate from awareness to action-taking, and the timeframe of customer progression from unaware to aware, and from aware to action. The final methods used in this study, however, are not targeted to develop appropriately detailed and reliable information on these topics. If NYSERDA wishes to evaluate this issue as part of its longitudinal examination, an additional data collection effort focusing on CHP system owners would likely be most appropriate, and could be framed to collect supplemental information about fees and labor associated with permitting.

[2] We also reviewed NYSERDA's DG-IDS database, which includes only those systems that are receiving a financial incentive from NYSERDA. Based on our review, it appears that the U.S. DOE database included additional systems not in the NYSERDA database, but the reverse was not true. Thus, the DOE database appeared to be more comprehensive.

2. Overview of the CHP Market in New York State

In this section, we present our findings characterizing the CHP market, including characteristics of CHP vendors, target markets, and penetration rate of CHP systems in New York State.

The supply side of the CHP market consists of original equipment manufacturers (OEMs), project developers (including engineering consulting firms), and contractors that install CHP equipment. Generally, vendors may assume one or more of these roles. Within this context, NYSERDA promotes modular CHP systems by including pre-approved CHP systems in its catalog of CHP systems ("the Catalog"). This catalog approach requires that these systems be installed by approved vendors in order to receive a financial incentive from NYSERDA. Vendors therefore serve as the primary point of contact between NYSERDA and the facility owner, and complete the application process on behalf of the owner to directly receive NYSERDA's incentive. In light of this dynamic, this market study focuses primarily on vendors, rather than other project developers or contractors.

Table 1 shows the number of employees, number of CHP systems installed, and revenues from CHP installations for the survey respondents. This exhibit shows nationwide data.

Table 1. Profile of CHP Vendors Active in New York State (Nationwide Data)

METRIC	AVERAGE	TOTAL	NUMBER OF RESPONDENTS
Employees (nationwide)	41.7 (range: 4 - 170)	417	10
Number of CHP Systems Installed	8.6	77	9
Annual CHP revenues	$6.75 million	$27.0 million	4

Notes: One vendor reported total annual revenues of $1 million, but revenue for non-Catalog systems of $6 million. We use the $6 million figure as a proxy for their total annual revenues. This most likely undercounts that vendor's actual revenues, since it implicitly assumes they had zero revenues associated with 3,000 kW of Catalog systems installed in 2015.
Source: Vendor survey.

Only four vendors provided revenue-related information. These vendors installed a total of 23 systems in 2015, both in and outside New York State, with an average system cost of $1.17 million per system.

2A. Activity in New York State

Table 2 Error! Reference source not found. shows the number of employees of CHP vendors in New York State, and average and aggregate capacity of CHP systems installed by the nine vendors active in 2015.

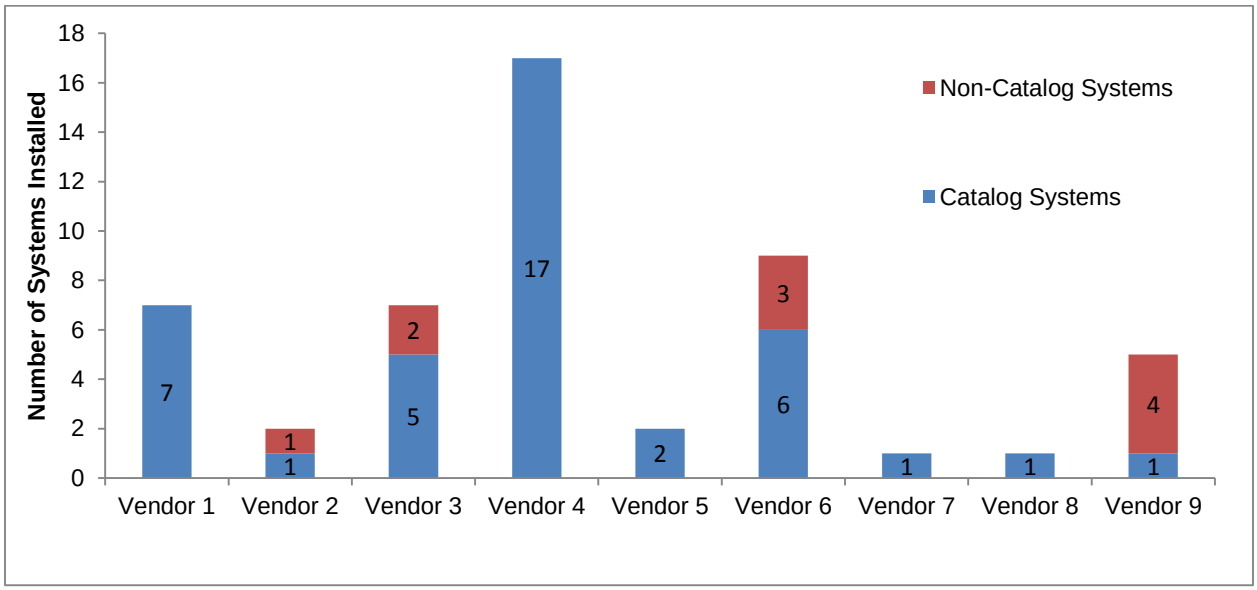
Table 2. CHP Vendor Activity in New York State, 2015

METRIC	AVERAGE	TOTAL	NUMBER OF RESPONDENTS
Employees	12 (range: 0 – 65)	116	10*
Number of projects	5.7	51	9
Capacity of CHP systems	247 kW	12.6 MW	9
Aggregate estimated system cost	Insufficient data	$21.2 million	5 (total of 12 systems)

Source: Vendor survey.
* Three respondents had no full-time employees in New York State.

A total of 51 systems were installed in New York State in 2015 by survey respondents; of these, 41 (80 percent) were Catalog systems. The average capacity of systems installed varies significantly across vendors. **Figure 1** shows the number of CHP systems installed by each respondent in New York State in 2015 classified by type of system.

Figure 1. Catalog and Non-Catalog CHP Systems Installed in 2015 by Vendor



Source: Vendor survey.

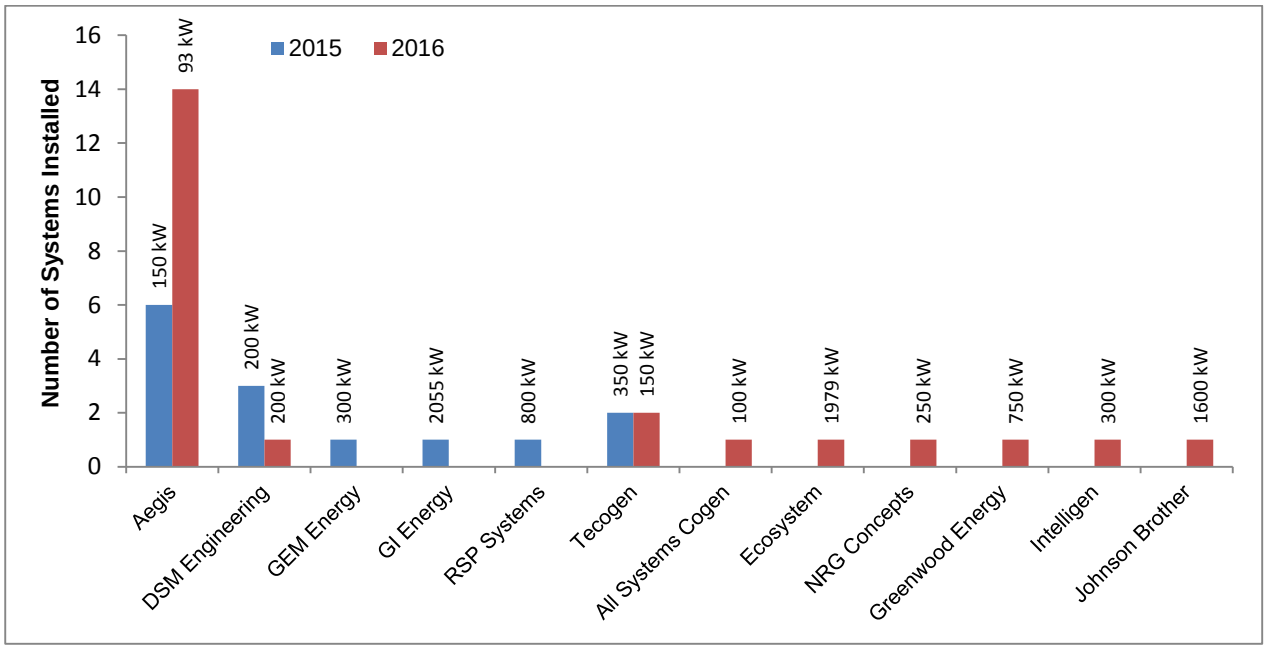
To augment survey responses, we used information from NYSERDA's DG-IDS database, U.S. DOE's CHP database, and CHP system commissioning reports received from NYSERDA. **Table 3** below compares system size and cost data from the different sources. Because only four survey respondents with a total of five Catalog systems and seven non-Catalog systems provided cost-related information, we did not have a sufficient basis to calculate the average cost per kW from survey data. According to the commissioning reports, CHP systems installed in 2016 had an average cost of $4,574 per kW.

Table 3. Characteristics of CHP Systems Installed in New York State in 2015

DATA SOURCE (NUMBER OF CHP SYSTEMS)	NUMBER OF CHP SYSTEMS (SAMPLE SIZE)	AVERAGE SYSTEM CAPACITY (KW)	AVERAGE COST PER SYSTEM	AVERAGE COST PER KW
Vendor survey: Catalog systems	41	243	$2.86 million [5 CHP Systems]	[Insufficient data]
Vendor survey: Non-Catalog systems	10	263	$0.99 million [7 CHP Systems]	[Insufficient data]
Commissioning reports	18	119 Median = 75	$ 552,641 Median = $410,458	$ 4,574
NYSERDA DG-IDS database	14	393 Median = 263		
U.S. DOE database	28	184 Median = 140		

Figure 2 shows data from the DG-IDS database identifying CHP systems commissioned in New York in 2015 and 2016. The DG-IDS database includes all systems receiving a financial incentive from NYSERDA. Project developers such as DSM Engineering Associates and GI Energy also installed NYSERDA incentivized CHP systems in 2015, but they were not included in the vendor survey since they primarily focus on the market for larger, generally custom (i.e., non-Catalog) CHP installations.

Figure 2. NYSERDA-incentivized Systems Commissioned in 2015 and 2016, by Installing Firm



Source: NYSERDA DG-IDS database.
Note: Data labels show the average capacity of installed CHP systems from each firm.

Together these data sources reveal a CHP market of modest size, served by a limited number of installers. Aegis appears to be the market's largest presence; the company installed 6 out of 14 systems and 14 out of 23 systems listed in the DG-IDS database for 2015 and 2016, respectively. Similarly, 15 of the 18 commissioning reports provided by NYSERDA (83 percent) were for Aegis systems. The remainder of the market is split across firms. Based on combined data from the vendor survey and the DG-IDS database, in 2015, we identified a total of 10 vendors and two project developers that installed CHP systems in New York State.

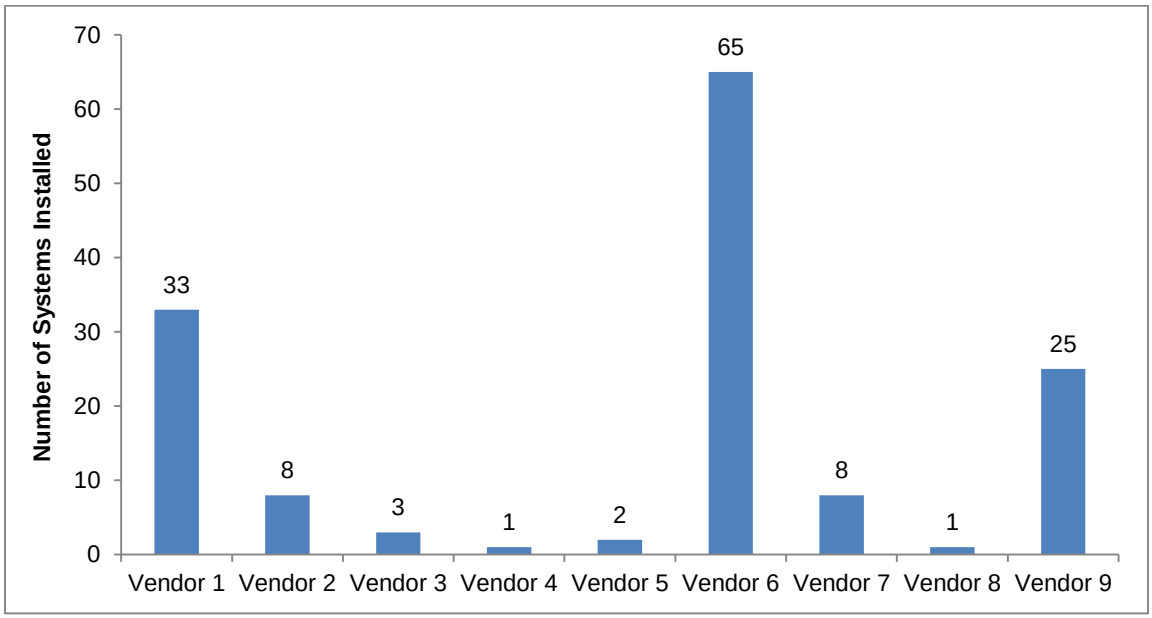
The market shows a high degree of concentration. To measure concentration, we use the Herfindahl-Hirschman Index (HHI), the same metric used by the Department of Justice and the Federal Trade Commission use when evaluating mergers. The HHI is calculated by squaring the market share of each firm in a given market and then summing the resulting numbers. The Department of Justice considers a market with an HHI of 0.25 or higher to be highly concentrated.[3] Since we do not have information on all market participants' revenues, we calculate the HHI using the number of CHP systems completed in 2015 and 2016 according to the DG-IDS database as a proxy for market share. This yields an HHI of 0.322, indicating that the CHP market in New York State is highly concentrated.

In addition to information specific to 2015, IEc gathered data on total installations in New York State to date. **Figure 3** summarizes respondents' cumulative installations in the state from 1995-present.[4]

[3] U.S. Department of Justice. "Herfindahl-Hirschman Index." Updated July 29, 2015. Available at: https://www.justice.gov/atr/herfindahl-hirschman-index Accessed March 20, 2017.

[4] According to ERS, the average lifetime of a CHP system is 20 years, and typically ranges from 10 years (smaller systems) to 30 years (larger systems). Thus, we have used 1995 as an estimate of the earliest installation year for which CHP systems installed would still be in operation at present.

Figure 3. Cumulative CHP Systems Installed, by Surveyed Vendor



Notes: One vendor listed here had zero installations in 2015, but had installations in prior years.
Source: Vendor survey.

Table 4 compares survey data with information retrieved from NYSERDA DG-IDS and U.S. DOE databases. The U.S. DOE database includes information on older systems than are in the DG-IDS database, which does not include any data prior to 2001. The U.S. DOE database also shows significantly higher average system size, potentially due in part to the influence of these earlier systems.

Table 4. Characteristics of CHP Systems Installed in New York State

DATA SOURCE	TIMEFRAME COVERED	NUMBER OF CHP SYSTEMS	AVERAGE SYSTEM CAPACITY (KW)
Vendor Survey	All years	146	521
NYSERDA DG-IDS database	2001 – present*	127	1,234
U.S. DOE database	1995 – present	446 [Includes one 250-MW district energy system]	2,810 [2,255 excluding district energy]
* The first CHP system in NYSERDA DG-IDS database was installed in 2001.			

Two factors may be driving the lower average system capacity from vendor survey responses:

- Survey respondents, especially those with greater numbers of installations, were more active in the New York City area, where the average size of CHP systems tends to be smaller in general.
- Respondents were primarily active in commercial facilities, which have smaller average system capacity than the industrial applications that are included in the two databases.

2B. Activity by Target Market

Table 5 shows facility types where respondents installed CHP systems in 2015 specifically, and from 1995 to present. As shown in the table:

- Average capacity per system for all defined target markets is significantly smaller in 2015 than for cumulative installations, suggesting that earlier CHP installations were larger, and the market is shifting to smaller systems.

- Multifamily buildings represent an area of recent focus, with 2015 installations representing a higher proportion of activity (68 percent of 2015 installations) than historical data suggest. CHP systems in multifamily buildings have a median capacity of 100 kW, based on U.S. DOE data, which likely contributes to the smaller average size of CHP systems installed in 2015.

Table 5. CHP Systems Installed by Target Market

TARGET MARKET	2015			CUMULATIVE (1995 – PRESENT)		
	NUMBER OF SYSTEMS INSTALLED	TOTAL CAPACITY INSTALLED (KW)	AVERAGE CAPACITY PER SYSTEM (KW)	NUMBER OF SYSTEMS INSTALLED	TOTAL CAPACITY INSTALLED (KW)	AVERAGE CAPACITY PER SYSTEM (KW)
Multifamily Buildings	26	4,050	156	35	9,000	257
Educational Institutions	1	350	350	29	14,975	516
Hotels	2	1,250	625	15	5,050	337
Hospitals	3	650	217	20	16,180	809
Offices	1	1,000	1,000	11	21,700	1,973
Assisted Living	0	0	--	10	1,710	171
Restaurants	0	0	--	0	0	--
Unknown/Other	18	5,293	495	26	7,565	291
Total	51	12,593	257	146	76,180	522

Source: Vendor survey.
Note: Thirteen systems were classified as "other" due to discrepancies in information provided in the vendor survey; it is likely that most of these systems were installed in the target markets noted above. The remainder was classified as "unknown." Based on installation data in the NYSERDA DG IDS database, it appears likely that the five "unknown" systems installed in 2015 were in the following markets: corrections; delivery service; healthcare linen service; lumber; museum; plastics processing; and combined residential/commercial.

2C. Penetration by Target Market

The penetration rate reflects the proportion of total technical potential of CHP that is actually installed, as shown in **Table 6**. To calculate the penetration rate for each target market, we used installation data from the U.S. DOE CHP database, including all installations from 1995 – present. We used market potential figures from the 2016 U.S. DOE study, *Combined Heat and Power (CHP) Technical Potential in the United States*. For ease of reference, we also include data collected from the vendor survey. Overall, CHP penetration in New York State stands at 12 percent of potential capacity and three percent of the total number of systems (i.e., at an average size of 0.58 MW, 16,455 additional systems could potentially be installed given existing available capacity in key areas in the market).

NYSERDA hypothesizes that the fast/casual restaurant market could ramp up due to the potential for small, "micro-CHP" systems. At present, this technology is too new to have documented penetration in this target market, but future installations in restaurants may be both higher in number and smaller in capacity than historic patterns.[5]

[5] Levy, Dana. Personal communication. March 16, 2017.

Table 6. Penetration Rate of CHP in New York State by Target Market

TARGET MARKET	CHP SYSTEMS INSTALLED (CUMULATIVE) - VENDOR SURVEY		CHP SYSTEMS INSTALLED, 1995-PRESENT		TECHNICAL MARKET POTENTIAL		PENETRATION RATE	
	NUMBER	CAPACITY (MW)	NUMBER	CAPACITY (MW)	NUMBER	CAPACITY (MW)	NUMBER	CAPACITY (MW)
Multifamily Buildings	*35*	*9*	120 [46]	63 [7]	2,301	510	5%	12%
Educational Institutions	*29*	*15*	78 [14]	156 [45]	1,592	1,011	5%	15%
Hotels	*15*	*5*	18 [10]	21 [5]	1,123	442	2%	5%
Hospitals	*20*	*16*	26 [12]	38 [26]	227	462	11%	8%
Offices	*11*	*22*	23 [9]	26 [14]	5,927	1,290	0.4%	2%
Assisted Living	*10*	*2*	41 [7]	11 [2]	547	141	7%	8%
Restaurants	*0*	*0*	1 [0]	0.12 [0]	465	57	0.002%	0.002%
Unknown/ Other	*26*	*8*	140 [39]	938 [69]	5,184	6,962	3%	13%
Total	*146*	*76*	446 [137]	1253 [169]	16,901	10,818	3%	12%

Sources:
1. Vendor data: vendor survey
2. CHP systems installed, 1995-present: U.S. DOE database. Figures in brackets represent data from NYSERDA DG-IDS database
3. Technical market potential: U.S. DOE, *Combined Heat and Power (CHP) Technical Potential in the United States, March 2016*
4. Penetration rate: calculated as CHP systems installed, 1995-present, divided by technical market potential

3. Soft Cost Characterization and Quantification

Soft costs or balance-of-system (BOS) costs reflect costs that are not considered to be direct equipment costs. A key objective of this study is to provide a baseline from which to measure changes in soft costs over time. To ensure a uniform basis of comparison, the survey provided vendors with definitions for 11 soft cost components, as reproduced in **Table 7**. IEc developed this list of soft costs and their definitions in consultation with NYSERDA, and designed to be roughly comparable to soft cost categories for other technologies (e.g., solar installations). Note that consistent with the Clean Energy Fund CHP Investment Plan, we focus on "soft costs" for CHP, rather than "balance-of-system costs," which include not just soft costs but also equipment costs ("hard costs") not directly attributable to the CHP system itself.

Table 7. Soft Cost Categories as Defined in Vendor Survey

SOFT COST COMPONENT	DESCRIPTION
Engineering	Cost of designing the system and integrating it with electrical and mechanical systems
Site preparation	Cost to prepare the site where CHP system will be installed (e.g. concrete flooring)
Installation labor/materials	Labor cost for the civil, mechanical, and electrical work and cost of materials such as ductwork, piping, and wiring
Rigging and coordination	Cost of items such as crane rental and use, insurance etc. associated with moving large CHP systems
Project and construction management	General contractor mark-up and bonding, and performance guarantees
Permitting fees	Fees related to procuring required permits
Permitting labor	Labor related to procuring required permits
Interconnection fees	Cost of interconnection and paralleling. For larger systems, this reflects the cost of paralleling a synchronous generator. For smaller systems, this may be included in the cost of equipment
Interconnection labor	Labor associated with interconnection
Financing	Cost, interest, and other charges involved in borrowing the money to purchase the system
Project Contingency	Reserve for unexpected expenses
Notes: Soft cost components that are sometimes included as part of a broader category are indented below that category.	

While the available literature does not set out a standard set of cost categories with consistent definitions, survey respondents uniformly indicated that they were able to use the definitions above to estimate costs. Respondents also indicated that these cost categories are generally applicable to all types of projects, and did not identify any missing cost categories.[6] The survey respondent with the highest number of installations highlighted that:

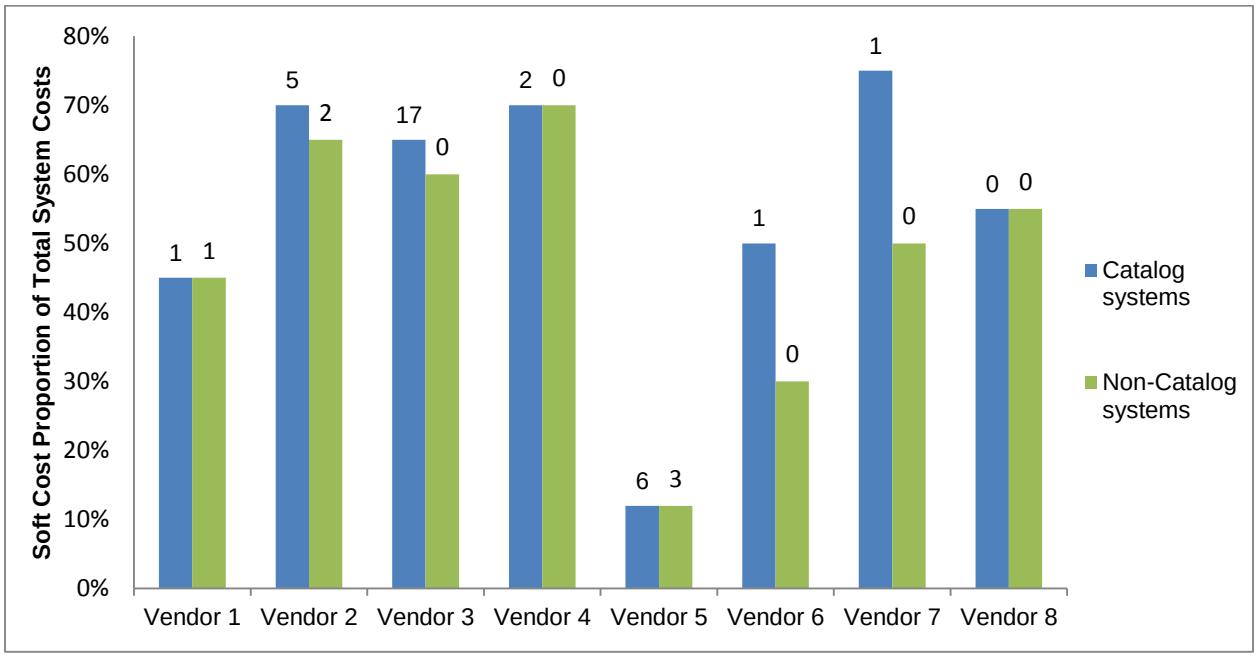
- Site preparation costs include sub-components such as boiler room renovation
- Financing and related contingency costs are incurred by the owner, and therefore are not usually incurred as a cost by the vendor.

3A. Soft Costs as a Proportion of Total System Cost

Survey respondents were asked to estimate the overall proportion of total CHP costs taken up by soft costs, as shown in **Figure 4**.

[6] The sole exception to this is that one vendor suggested an additional cost category of "cogen to building control interface." This vendor had installed only one CHP system in New York State.

Figure 4. Soft Costs as a Proportion of Total System Costs, by Vendor



Notes: Data labels indicate the number of CHP systems installed in 2015 by the each respondent.
Source: Vendor survey.

As shown in the figure above, most vendors indicated that soft costs accounted for either the same or a slightly higher proportion of total system costs for Catalog systems as compared to non-Catalog systems. Only two vendors indicated that soft costs accounted for a significantly higher proportion of total system costs in Catalog systems. There are several possible explanations:

1. As noted above, Catalog systems are, on average, smaller than non-Catalog systems. To the extent that some soft costs are fixed (i.e., they do not vary with system size), soft costs will make up a larger proportion of total system costs for smaller systems.
2. The two vendors that reported a substantial difference did not have any non-Catalog systems installed in New York in 2015. Costs could have changed since the last time they had installed a non-Catalog system, and that change could be reflected in the reported differential between Catalog and non-Catalog systems.
3. As discussed below, the survey probed on the major categories of soft costs for Catalog and non-Catalog systems. One of the vendors reporting a substantial difference in the proportion of total system costs accounted for by soft costs indicated that project and construction management was a significantly higher proportion of soft costs in Catalog systems; this is based on their experience with a single Catalog system installed in 2015. Thus, that particular CHP system may have had a site-specific issue that led to higher project and construction management costs. For the other vendor, the higher soft costs in Catalog systems were not due to any specific cost category, but instead reflected higher costs across the board; again, this was based on their experience with a single Catalog system installed in 2015.

IEc weighted the survey responses based on the number of Catalog and non-Catalog systems respectively installed by each survey respondent, shown in **Table 8**. The weighted average drastically decreased for non-Catalog systems, due primarily to one major vendor that reported soft costs significantly lower than the other vendors.

Table 8. Average Soft Costs as a Proportion of Total System Costs

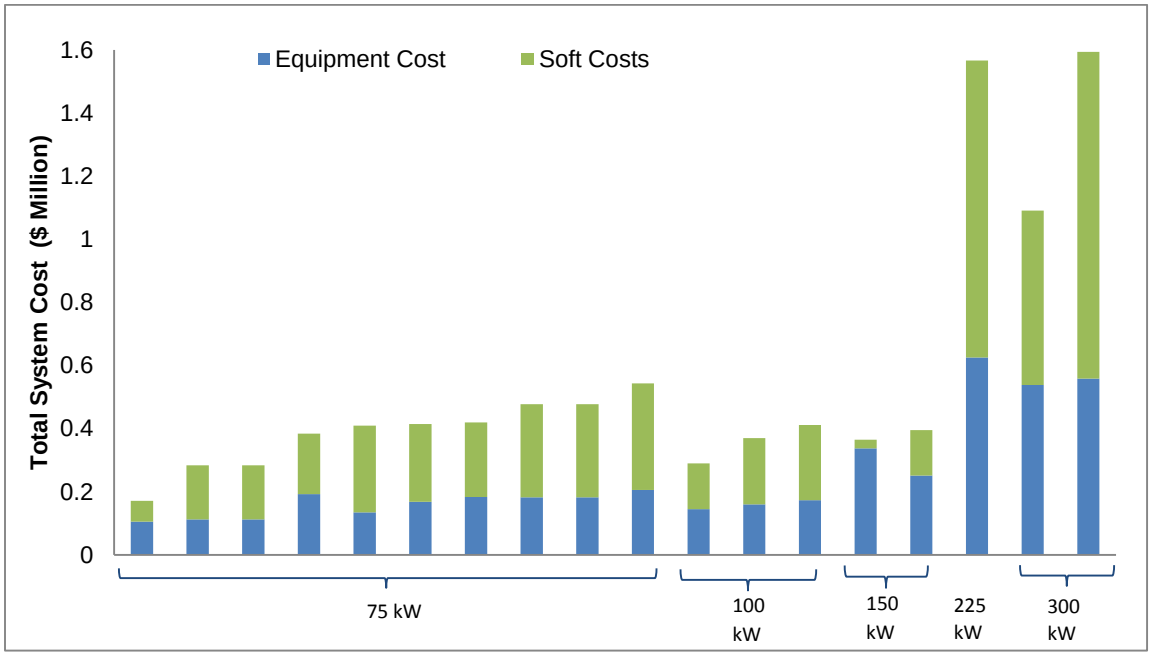
TYPE OF SYSTEM	SOFT COSTS AS PROPORTION OF TOTAL SYSTEM COSTS	
	UNWEIGHTED AVERAGE	WEIGHTED BY NUMBER OF SYSTEMS INSTALLED
Catalog Systems	55%	56%
Non-Catalog Systems	48%	35%

Notes: excluding Vendor 5, which had abnormally low cost estimates, the weighted average would be 65% for Catalog systems and 58% for non-Catalog systems. The unweighted average would be 61% for Catalog systems and 54% for non-Catalog systems.
Source: Vendor survey.

NYSERDA commissioning reports received also provided a breakdown of equipment cost and soft costs. These reports are all for systems that are 300 kW or smaller; 17 of the 18 are Catalog systems. On average, soft costs from the commissioning reports constituted 53 percent of total system costs, nearly identical to survey results for Catalog systems.[7]

Figure 5 and **Figure 6** show the total cost of CHP systems from the commissioning reports. Figure 5 presents total dollars, while Figure 6 shows the proportion of the total accounted for by equipment costs and soft costs respectively. Across all systems, the average total cost was $552,641 and the average soft cost was $310,020.

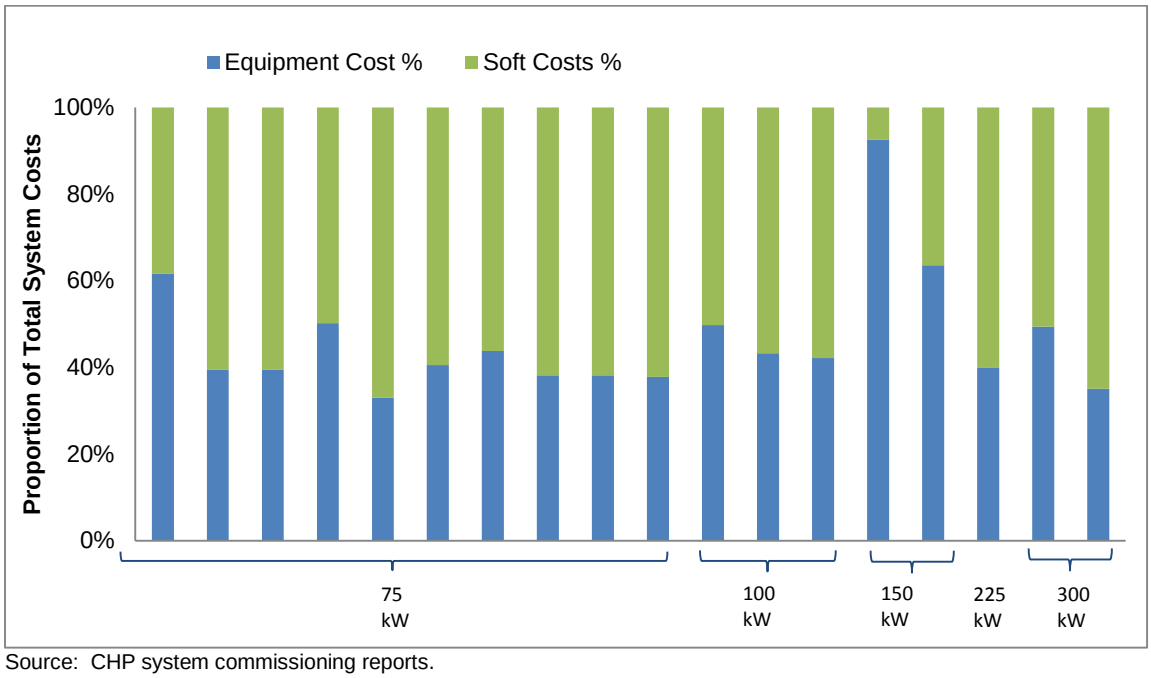
Figure 5. Total Soft Cost and Equipment Cost for CHP Systems



Source: CHP system commissioning reports.

[7] Excluding the one non-Catalog system, the average soft costs from the remaining commissioning reports are still 53 percent of total system costs.

Figure 6. Soft Cost and Equipment Cost as Proportions of Total Cost



Source: CHP system commissioning reports.

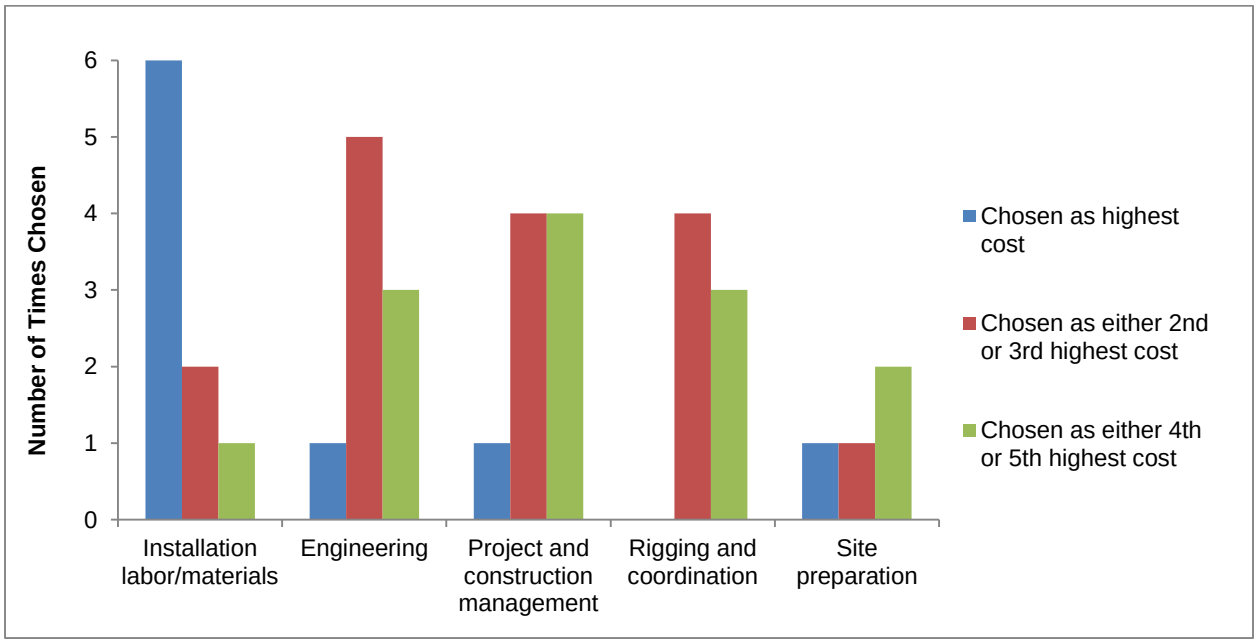
We also analyzed soft costs based on size class, based on the commissioning reports. Excluding the 225 kW system, which has an unusually high total cost of approximately $7,000/kW, the other systems in the commissioning reports provide a fairly consistent equipment cost, with a weighted average of $2,010/kW. The weighted average soft cost is $2,613/kW, but varies significantly between systems.

3B. Relative Importance of Soft Cost Components

Survey respondents ranked the five largest categories of soft costs from the 11 soft cost categories identified earlier in **Table 7**. Figure 7 shows the soft cost categories that were chosen most frequently by survey respondents. This ranking is based on responses from nine vendors, eight of which installed CHP systems in 2015. The five soft cost components shown dominated the responses, with installation labor/materials reported as the highest soft cost component by six respondents.[8]

[8] The other soft cost components chosen at least once by survey respondents among their top five components are rigging and coordination, interconnection fees, and permitting fees.

Figure 7. Ranking of Soft Cost Categories

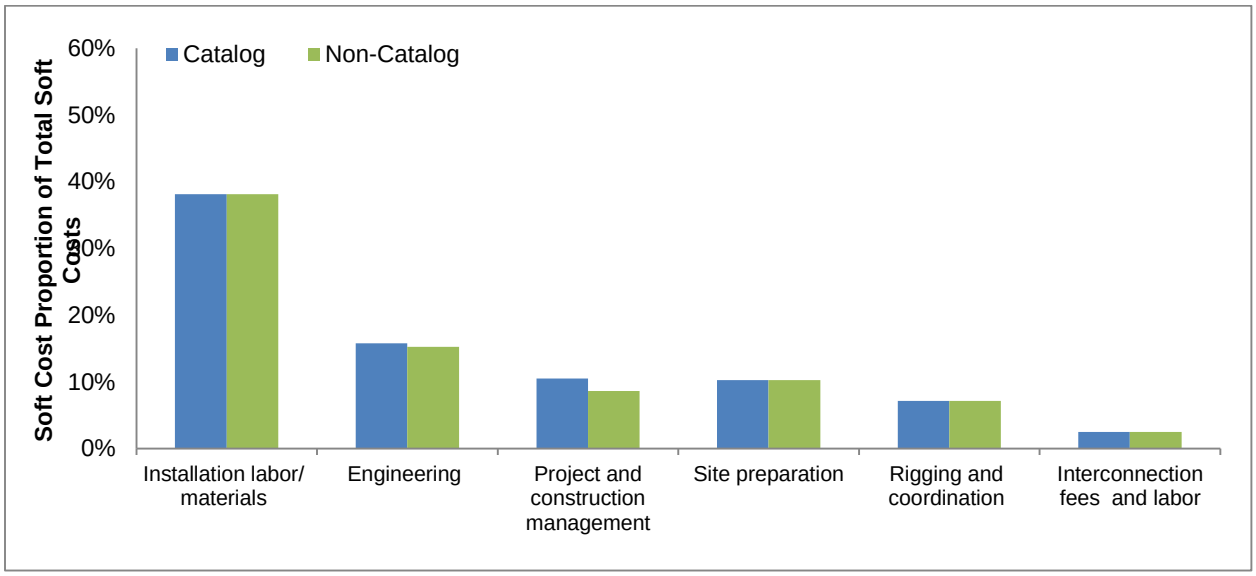


Source: Vendor survey.

In addition to ranking soft cost categories, survey respondents estimated each cost component's contribution to total soft costs. Respondents ranked only the five most significant cost categories they had identified, and (separately) interconnection fees and labor. As shown in **Figure 8**, the results did not differ significantly between Catalog and non-Catalog systems. The largest soft cost components in terms of proportion of overall cost are installation labor/materials, engineering, and site preparation. Consistent with the ranking shown in the previous figure, installation labor/materials accounted for by far the largest proportion of total soft costs.

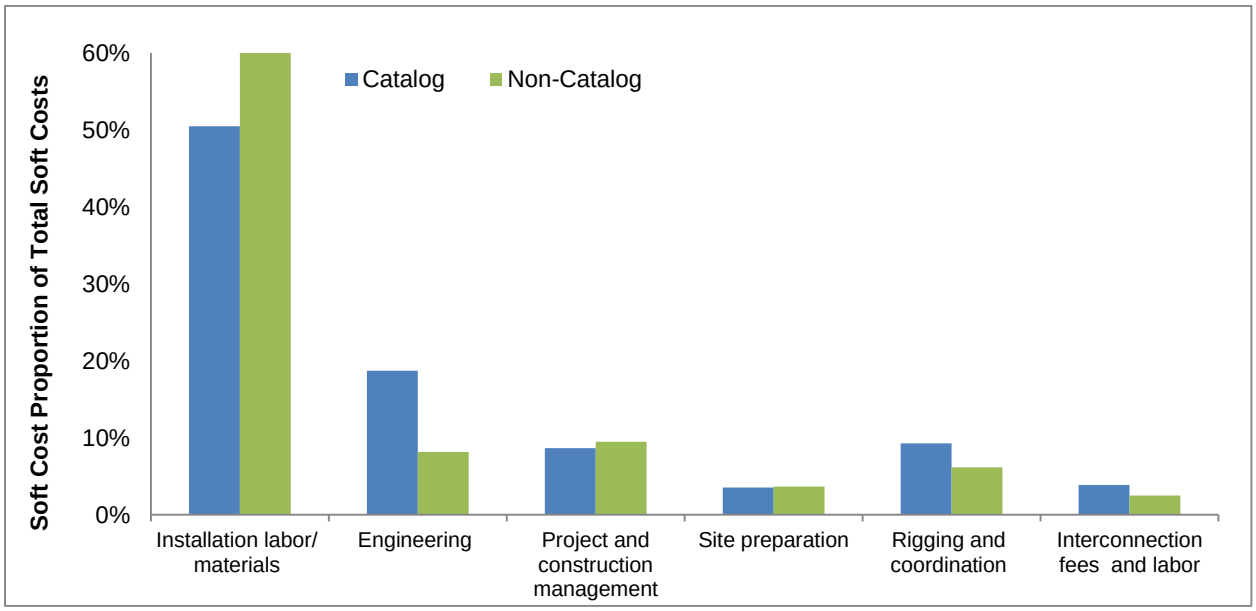
We weighted these responses by the number of CHP systems installed by each respondent; the results are shown in **Figure 9**. Some costs – particularly engineering, rigging, coordination, and interconnection costs – are largely fixed (i.e. they do not vary across system size). These costs therefore represent a higher proportion of total costs for Catalog systems, which tend to be smaller than non-Catalog systems. Installation labor and materials is proportional to the size of the CHP system, and non-Catalog systems therefore tend to have higher installation labor/materials cost as a proportion of total soft costs.

Figure 8. Soft Cost Categories as a Proportion of Total Soft Cost



Source: Vendor survey.

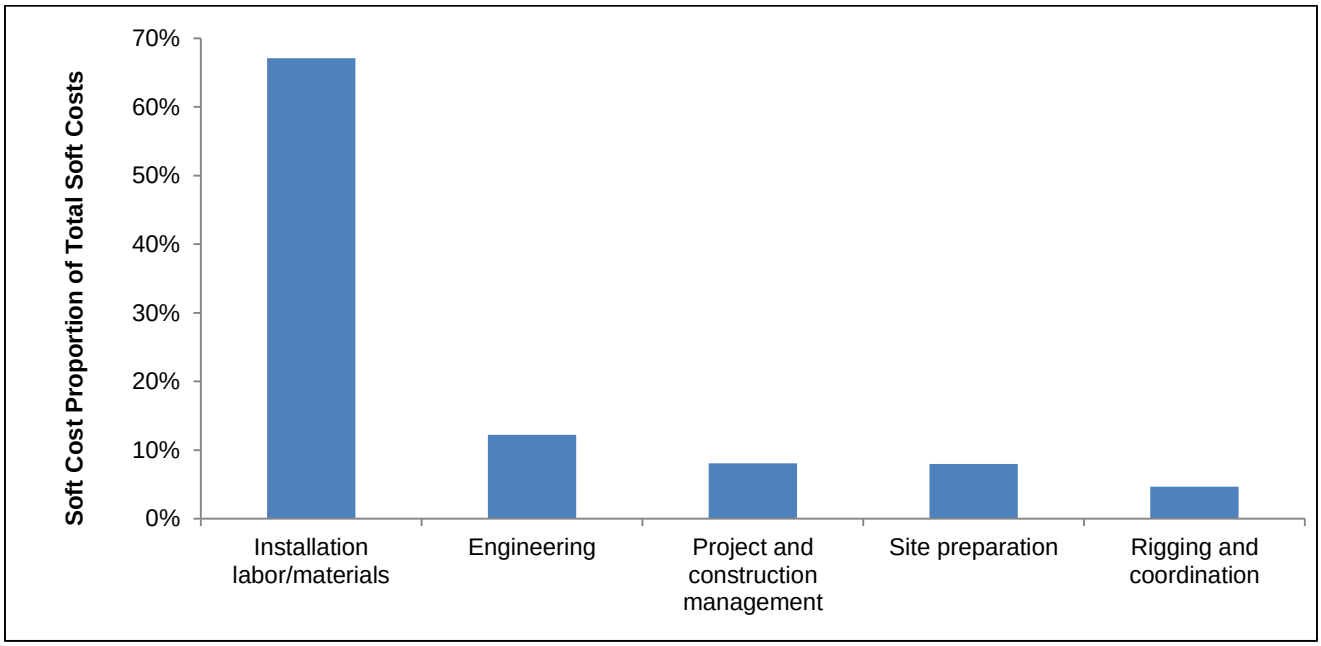
Figure 9. Soft Cost Categories as a Proportion of Total Soft Cost (Weighted by Number of Systems Installed)



Source: Vendor survey.

As noted above, one vendor installed 15 of the 18 systems for which commissioning reports were provided. This vendor included a breakdown of soft cost components in addition to the overall proportion of soft costs. We mapped these soft costs to the categories in the vendor survey, shown in **Figure 10**. The results are largely consistent with the cost information from the survey shown in Figure 9**.**

Figure 10. Soft Costs from A Major Vendor's Commissioning Reports



Source: CHP system commissioning reports.

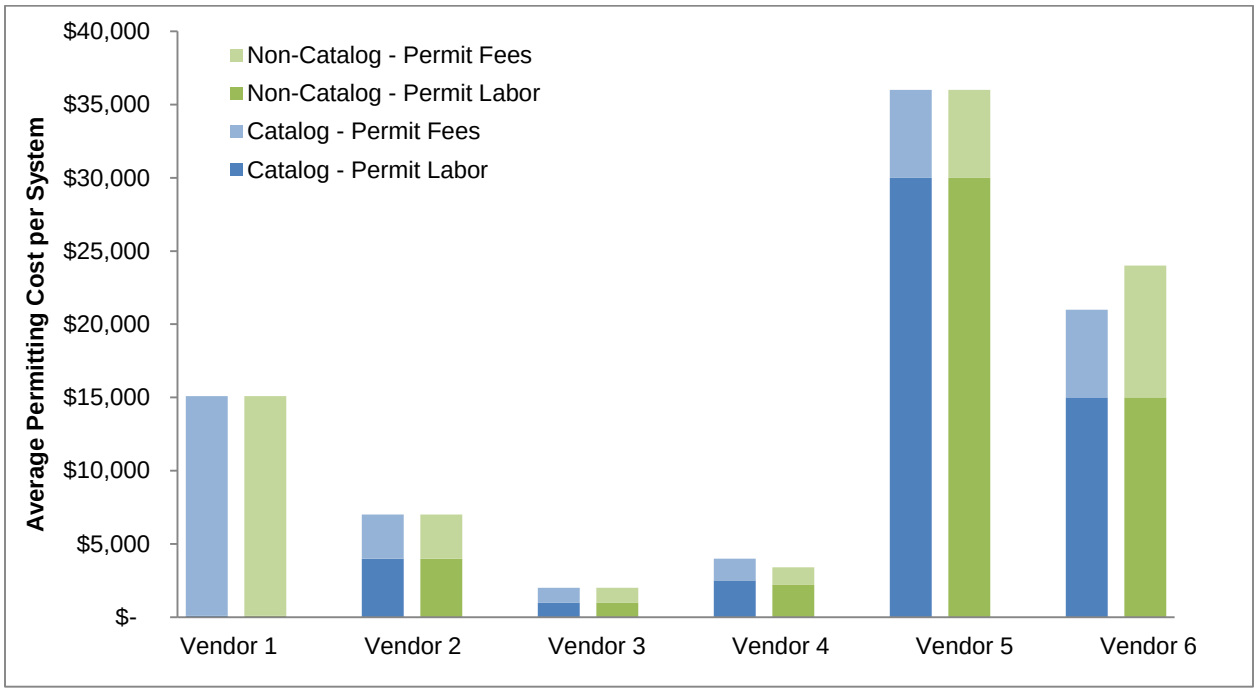
3C. Other Findings

3C.1 Permitting Costs

In addition to the general information on soft costs discussed above, IEc collected data through the vendor survey on permitting labor and fees. **Figure 11** presents survey respondents' estimates of average permitting costs. Despite extensive outreach to non-respondents, only six firms provided information in response to this survey question. Furthermore, the answers provided show significant variability; while the average costs are $8,767for labor and $5,417 for fees for Catalog systems and $8,717 for labor and $5,867 for fees for non-Catalog systems, individual responses varied dramatically. One reason for this variability may be that permit fees are generally paid by system owners, not vendors; thus, vendors may not have direct experience from which they can estimate this particular cost component, as they do for other soft costs. Geographic differences may also influence results, since permitting requirements vary by city; differences in system size may play a similar role. For these reasons, we have a lower degree of confidence in the average figures reported above than we do for our other soft cost results. Even so, both the averages and the degree of variation reported here provide a starting point for NYSERDA to compare to future results.

The vendor survey also requested information on permit-related delays, but we received limited information on this issue. Three vendors indicated that they waited an average of zero, 30, and 60 days respectively for permit approval for Catalog projects, while two vendors stated that they waited an average of zero and 60 days respectively for permit approval on non-Catalog projects (for an overall average of 30 days for both Catalog and non-Catalog systems). Due to the low response rate and the high degree of variability, we do not have a high degree of confidence in these results.

Figure 11. Average Permitting Fees and Labor



Source: Vendor survey.

3C.2 Warranty Costs

IEc collected survey data on the proportion of total system cost needed to meet NYSERDA's five year warranty requirement for Catalog systems. Survey responses indicated that the average proportion of total cost incurred as warranty is approximately 12 percent over five years, but responses vary significantly; as a result, we have a low degree of confidence in this average figure. In follow-up conversations, one vendor noted that their estimated was driven by the maintenance plans they provide on CHP systems. Depending on the size of CHP system and the plan chosen by the customer, this vendor's cost of maintenance plan for five years ranges from 12 percent (for smaller systems with only the NYSERDA-mandated warranty plan) to 20 percent (for larger systems with extended factory protection plan) of the total system cost.

3C.3 Potential Opportunities to Reduce Soft Costs and Increase Penetration of CHP

IEc conducted a limited number of interviews with selected survey respondents and other CHP market participants regarding opportunities to reduce soft costs and increase penetration of CHP. In this section, we briefly summarize our findings from those discussions.

Vendors noted that costs such as engineering, project and construction management, and permitting and interconnection fees, are similar for both Catalog and non-Catalog projects, and do not vary proportionally with the size of CHP system (though soft costs as a whole may constitute a larger proportion of total costs for smaller systems). One vendor said that despite the pre-approval of Catalog systems by NYSERDA, engineering is still required to suit the requirements of the facility owner. Since Catalog systems tend to be smaller than non-Catalog CHP systems, these cost components constitute a higher proportion of the total system cost.

One respondent noted that costs differ significantly for a simple cogeneration technology and for cogeneration technology with an emergency generator. PON 2568 requires that NYSERDA-incentivized CHP systems include an emergency generator, which increases the cost of NYSERDA-incentivized CHP systems.

IEc interviewed two experts in the CHP industry to understand the potential for including CHP as part of a real estate or refinancing transaction. One interviewee, who plays an active role in the New England Combined Heat and Power Initiative (NECHPI) highlighted the complexity and well-established nature of real estate transaction processes. He stated that the inclusion of another complicated process of real estate commissioning that includes permitting and interconnection would be difficult, and he therefore envisions limited opportunity to combine the two processes. One of the surveyed vendors also opined that combining CHP and real estate transactions would be complicated, and stated that in their experience, it was more typical to install a CHP system after the real estate transaction is completed.

Another vendor suggested that there may be an opportunity to install CHP systems when facilities with a sizeable load requirement, such as hospitals, request a load increase from their utility. CHP vendors could provide additional capacity for the customer in a faster timeframe than a load increase by the utility.

4. Conclusions and Recommendations

Our key findings are as follows.

1. The penetration rate for CHP remains relatively low among NYSERDA's target markets. This indicates that there is still significant opportunity for increased use of CHP across sectors. Sectors with the greatest penetration rates are educational institutions and multifamily buildings, which have reached 12 – 15 percent of technical potential. Penetration rates in other target markets range from 0 – 8 percent in capacity terms. The overall penetration rate is 12 percent of technical potential.
2. The market is dominated by a few players and demonstrates a high degree of concentration. According to NYSERDA's DG-IDS database, four vendors completed CHP systems in New York State in 2015 and seven vendors completed systems in 2016. A single vendor also provided a strong majority of the commissioning reports NYSERDA received for projects completed in 2016. No other firm had more than two projects completed in 2016, according to either the DG-IDS database or the commissioning reports.
3. Each category of soft costs is fairly consistent across projects and firms. Vendors consistently identified major categories of soft costs as installation labor/materials; engineering; rigging and coordination; and project and construction management. While some vendors indicated lower average costs for certain categories of soft costs for non-Catalog systems, this appears to be driven by size differences (non-Catalog systems are, on average, larger than Catalog systems).
4. Survey data indicate that soft costs average 56 percent of total CHP system costs for Catalog systems. Soft costs accounted for 53 percent of total CHP system costs in the commissioning report data. For non-Catalog systems, survey data show that soft costs average 35 percent of total system costs. This is likely due to system size differences; it appears that soft costs are similar for similarly-sized Catalog and non-Catalog systems.
5. We have limited information regarding possible links between real estate financing and CHP financing. However, based on a small number of interviews with market participants, it appears that there is little if any opportunity to combine real estate and CHP financing into a single transaction, due to the complexities involved.

Appendix A. Methods

This appendix discusses the methods used for this study. Our primary methods included a review of existing literature and other data sources; a web-based survey of CHP vendors with phone follow-up; and additional phone interviews with other market participants.

A.1 Initial Review of Literature and Secondary Data

In December 2014, IEc completed an Evaluation Readiness Review (ERR) of NYSERDA's CHP Aggregation & Acceleration Program. In this ERR, and in subsequent scoping activities undertaken for the current study, IEc conducted meetings with NYSERDA and ERS and reviewed documents from the NYSERDA CHP program and other sources that informed the current evaluation. **Appendix B** lists the sources reviewed.

A.2 Vendor Survey and Follow-up

The primary data collection effort for this market study consisted of a web-based survey of CHP vendors active in New York State. For the survey sample, IEc developed a list of all CHP vendors active in the state, based on two criteria:

1. All vendors that had pre-approved systems in the then-current NYSERDA CHP Catalog
2. Vendors that had installed CHP systems in 2015 or 2016 based on NYSERDA's DG-IDS database

IEc also attended NYSERDA's On Site Power Conference and Expo on December 7-8, 2016, and added other CHP vendors in attendance at the conference to the survey sample. Finally, IEc consulted with ERS to confirm that no other firms were currently active in New York State. There were 22 firms in the sample frame when the survey was launched, but four of these were subsequently found to be ineligible and were removed. Thus, the final sample frame comprised 18 firms.

IEc developed a draft survey instrument in consultation with ERS, NYSERDA program and evaluation staff, and APPRISE, a research institute specializing in survey development and administration. The survey covers three primary areas:

1. Basic company information and CHP installations in New York State, including by target market
2. Characterizing and quantifying balance-of-system (BOS) costs
3. Other factors influencing CHP adoption

APPRISE programmed the survey for web use and pre-tested it with three vendors in the first week of January 2017. The survey instrument was finalized based on feedback from the pre-test participants. The final instrument is reproduced in **Appendix C**. APPRISE administered the survey between January 17 and February 6, 2017.

Table 9 summarizes the final survey disposition. Two firms completed most, but not all, of the survey via the web form; we were able to gather the remaining information from these vendors through phone follow-up. As a result, we have counted their survey responses as complete for purposes of calculating the response rate.

Table 9. Survey Disposition

STATUS	COUNT
Initial Sample	22
Removed from Sample (no CHP installation in New York State in 2015)	4
Remaining Sample	**18**
Not Responsive	6
Incomplete	3
Largely Complete (fully complete with phone follow-up)	2
Fully Complete	7
Response Rate (9 completions out of 18 firms in sample frame)	**50%**

The survey respondents providing complete information included:

- Three out of four vendors with systems installed in 2015 listed in NYSERDA's DG-IDS database, accounting for 74 percent of installed capacity[9]
- Six out of 11 approved vendors with CHP systems listed in the NYSERDA CHP Catalog (as of May 2016)
- Four out of five vendors identified by ERS as being active in the New York City CHP market

Further, it is important to note that only one of the firms represented among the non-responses and incompletes was listed in NYSERDA's DG-IDS database for 2015. While some of the remaining non-responsive firms may have, in fact, had CHP systems installed in 2015 that were not represented in the database, we believe that many, if not most, of these firms simply did not have any such systems. If true, they would not be included in the final sample, which currently stands at 18 firms. Removing these firms would have the effect of increasing our response rate from the 50 percent figure listed here. Thus, we believe that the responses provided are generally sufficient to characterize the CHP market in New York State. In sections 2 and 3, we have noted specific results where we have less confidence in our results due to a smaller number of responses (because not all respondents answered all questions in the survey).

After the web survey was concluded, IEc conducted follow up by phone to seek clarification and potential correction of certain anomalous responses. In sections 2 and 3, we have noted anomalous responses that we were unable to validate through these efforts.

A.3 Phone Survey of Vendors Inactive in 2015

Four survey respondents indicated that they had not installed any CHP system in the state in 2015, and were therefore removed from the sample frame. To gather additional information on soft costs, we attempted to conduct phone surveys with these four vendors. Two of the four vendors had been added to the CHP Catalog in May 2016, but had not installed any CHP systems in New York State; we therefore did not collect any further information from them. We gathered information from the two remaining vendors regarding soft costs in New York State. Both of these vendors are included or pending approval to be included in the NYSERDA CHP Catalog.

A.4 Expert Interviews

IEc met with CHP experts during NYSERDA's On-Site Power Conference and Expo in December 2016. We reached out to these experts to explore market factors that affect CHP project timing, and to identify

[9] In addition to these four vendors, two non-vendor installers had CHP systems in NYSERDA's DG-IDS database for which monitoring began in 2015. Including those installers, our sample represents three out of six entities and 37 percent of installed capacity listed in DG-IDS for 2015.

whether bundling the financing of CHP into a larger transaction could provide opportunities to increase the penetration of CHP in New York State. We conducted two interviews with representatives from NECHPI and EnergizeNY Finance to gather information regarding the inclusion of CHP financing as part of a real estate transaction, and other financing opportunities. We also discussed other issues and opportunities regarding CHP with these experts.

A.5 Review of Additional Data Sources

In addition to the initial data review noted above, IEc reviewed additional specific data sources for the purposes of:

1. calculating market penetration rates, and
2. validating and expanding on the cost quantification data collected through the survey.

For the penetration rate, IEc reviewed market potential studies and databases listing the systems actually installed. For cost data, IEc reviewed commissioning reports submitted to NYSERDA by vendors. These reports were required in order for the vendors to receive the final portion of the financial incentive offered by NYSERDA for qualifying installed systems.

Penetration Rate Data

Penetration rates are calculated by dividing the total number of systems or capacity installed in a given market (e.g., multifamily buildings in New York State) by the total potential size of that market. Potential can be defined in different ways, but for this study, we have used technical potential, meaning that only technical and not economic limits are used to determine the circumstances in which CHP would be feasible.

We relied on data from a 2016 U.S. DOE study for our estimates of market potential by target market.[10] This study separately includes the estimate of district energy CHP in its assessment of technical potential, which has a significantly larger capacity per unit as compared to other commercial CHP applications. We included the estimate for district energy component in the calculation of overall penetration rate of CHP.

We also reviewed a 2002 market potential study conducted for NYSERDA, which reported the total remaining market potential in New York State (i.e., excluding systems that were already installed as of 2000).[11] However, in consultation with ERS, IEc determined that the 2016 DOE study represented a better estimate of market potential, since it incorporates the changes that have occurred in recent years, such as reduction in average size of CHP systems, including for the interest target markets. Also, the 2016 study does not rely on the number of CHP systems currently installed, but instead reports the total technical potential of CHP. We therefore used the DOE study as the basis for our penetration rate calculations.

We used the U.S. DOE Combined Heat and Power Installation Database to determine the total number and capacity of CHP systems installed in each target market. We used two assumptions to compare vendor survey responses for CHP target markets with this database:

- The data on nursing homes in the U.S. DOE database are comparable to the Assisted Living target market in vendor survey responses
- Survey respondents assumed that educational institutions include both schools and colleges/universities, which are listed as separate facility types in the U.S. DOE database

[10] "Combined Heat and Power (CHP) Technical Potential in the United States." U.S. Department of Energy, March 2016. Available at https://www.energy.gov/eere/amo/downloads/new-release-us-doe-analysis-combined-heat-and-power-chp-technical-potential.

[11] Hedman, Bruce, Ken Darrow, and Tom Bourgeois. "Combined Heat and Power Market Potential For New York State." Prepared by Energy Nexus Group Onsite Energy Corporation and Pace Energy Project for the New York State Energy Research And Development Authority, October 2002. NYSERDA Report 02-12. Available at https://www.nyserda.ny.gov/-/media/Files/EERP/Combined-Heat-and-Power/chp-market-potential.pdf

We also reviewed NYSERDA's DG-IDS database for this purpose; the NYSERDA database includes all CHP systems that received a financial incentive. In each of the target markets examined, the DOE database had additional CHP systems that were not listed in the NYSERDA database; the reverse was not true. We therefore determined that the DOE database was a more comprehensive source, and used it in our calculations. Note, however, that to the extent there are CHP systems installed in the state that are not listed in the DOE database, our results would understate the actual penetration rate.

We calculated penetration rates for both number of systems and installed capacity in two ways:

1. Including all CHP systems in the DOE database. This approach implicitly assumes that all systems that have been installed are currently operational (or that non-operational systems do not appear in the DOE database).
2. Including only CHP systems installed since 1995. This approach assumes that CHP systems have a roughly 20-year lifespan on average, such that systems installed earlier than that are no longer in operation.

Cost Data

IEc collected and analyzed cost data from a series of commissioning reports on specific CHP systems. These reports address all CHP systems installed in 2016 that received a financial incentive from the NYSERDA CHP program, as well as a limited number of systems installed in 2014 and 2016. IEc reviewed 18 commissioning reports in total, of which 15 were for systems developed by a single vendor.

IEc calculated the average total cost, average equipment cost, and average soft costs from these commissioning reports, as well as average system size. Because not all vendors classified soft costs in the same manner, we were unable to calculate average costs for individual soft cost components across all commissioning reports. However, one vendor, which provided the vast majority of the reports, did use a consistent classification system; we therefore calculated the average cost for each of the cost components reported by that major vendor across those 15 reports.

Appendix B. Bibliography

Energetics Incorporated. 2009. The Contribution of CHP to Infrastructure Resiliency in New York State. Prepared for the New York State Energy Research and Development Authority. April 2009.

Energy Nexus Group Onsite Energy Corporation and Pace Energy Project. 2002. Combined Heat and Power Market Potential for New York State. Prepared for the New York State Energy Research and Development Authority. October 2002.

ERS. 2015. Distributed Generation – Combined Heat and Power Impact Evaluation Report (2001 – June 2011). Prepared for the New York State Energy Research and Development Authority. March 2015.

Garland, Patti. 2012. United States Department of Energy CHP Deployment Program Activities. Oak Ridge National Laboratory. Presentation: NYSERDA's CHP Conference. 22 June 2012.

Gerrad, Michael B. 2013. Reducing Legal Hurdles to Combined Heat and Power in New York. New York Law Journal. Volume 249 no. 88. 8 May 2013.

ICF International. 2012. Combined Heat and Power: Policy Analysis and Market Assessment. Prepared for California Energy Commission. February 2012.

ICF International. 2013. Guide to Using Combined Heat and Power for Enhancing Reliability and Resiliency in Buildings. Prepared for U.S. Department of Energy, U.S. Department of Housing, and U.S. Environmental Protection Agency. September 2013.

KEMA Inc, Itron, and Energy & Resource Solutions. 2011. Final Report Project 1C Combined Heat & Power Market Characterization: Massachusetts Energy Efficiency Programs' Large Commercial & Industrial Evaluation. Prepared for the Massachusetts Energy Efficiency Program Administrators. 1 June 2011.

Mattison, Lauren. 2006. Technical Analysis of the Potential for Combined Heat and Power in Massachusetts. Center for Energy Efficiency and Renewable Energy, University of Massachusetts Amherst, Department of Mechanical and Industrial Engineering. May 2006.

National Association of State Energy Officials. 2013. Combined Heat and Power: A Resource Guide for State Energy Officials. Prepared for U.S. Environmental Protection Agency.

Navigant Consulting, Inc. 2011. Distributed Generation — Combined Heat and Power Demonstration Program: Market Characterization and Assessment Report. Prepared for the New York State Energy Research and Development Authority. 29 August 2011.

New York State Energy Research and Development Authority. 2013. CHP Acceleration Program. Program Opportunity Notice (PON) 2568.

Onsite Sycom Energy Corporation. 2000. The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector. Prepared for the United States Department of Energy. January 2000.

Pace University Energy Project and Energy and Environmental Analysis. 2003. Clean Distributed Generation in New York State: State and Local Siting, Permitting and Code Issues. Prepared for the New York State Energy Research and Development Authority. May 2003.

PACENow. 2013. Introduction to Commercial PACE Potential for CHP. 26 June 2013.

Saba, Alexis; Howard, Bianca; Gerrard, Michael; Modi, Vijay. 2013. The Opportunities for and Hurdles to Combined Heat and Power in New York City. Center for Climate Change Law and Modi Research Group at Columbia University. May 2013.

Shibata, Mei. 2016. CHP and Fuel Cells 2016-2026: Growth Opportunities, Markets and Forecast. May 2016.

U.S. Department of Energy and U.S. Environmental Protection Agency. 2012. Combined Heat and Power: A Clean Energy Solution. August 2012.

U.S. Department of Energy Mid-Atlantic Clean Energy Application Center. 2010. New Jersey Combined Heat and Power Market Assessment. Prepared on behalf of the New Jersey Board of Public Utilities. 10 November 2010.

U.S. Department of Energy Mid-Atlantic Clean Energy Application Center. 2010. Maryland Combined Heat and Power Market Assessment. 27 October 2010.

U.S. Department of Energy. 2016. Combined Heat and Power (CHP) Technical Potential in the United States. March 2016.

Appendix C. Survey Instrument

NYSERDA Combined Heat and Power (CHP) Survey

Welcome to the NYSERDA Combined Heat and Power (CHP) Market Characterization Survey! NYSERDA's CHP program aims to reduce costs and development time and increase the penetration of CHP. You have been selected to participate in this important research effort to collect information about the CHP market in New York State.

This survey takes approximately 15 minutes to complete. The information you provide will be kept confidential to the extent permitted by law. All information shared with NYSERDA will use summary level data, and will not identify individual respondents or firms without first obtaining your written approval.

Please click **"Start"** to begin the survey.

Introductory Material

1. Did your company install or assist in installing CHP systems in New York State in 2015?
    1. Yes
    2. No
    3. Don't know

[If no: "Based on your response, you are not eligible for this survey. Thank you for your time and willingness to participate!" then Terminate.]

[If don't know: "This survey is focused on your organization's CHP installation projects in New York State in 2015. If you are not familiar with this and know someone else in your organization who is knowledgeable about your recent work in New York State, please forward your survey invitation e-mail to that individual and click the "next" button to return to the beginning of the survey." then Terminate.]

2. Are you familiar with your company's work to install CHP systems in New York State in 2015?
    1. Yes [SKIP TO Q4]
    2. No
3. ***[ASK if Q2=2]*** Can you provide contact information for someone at your company who would be more familiar with your company's work to install CHP systems in New York in 2015?
    1. Yes [If selected, provide open-end box for name, box for phone, box for e-mail]
    2. No

[If Q3=1 or 2: "Thank you for your time and willingness to participate. Have a nice day."]

Company Overview and Size

4. What is your company's name?
5. Approximately how many total employees (FTE) does your company have in the United States? Your best estimate is fine. *[PROGRAMMER: set range from 1 to 100,000]*
6. Approximately how many employees (FTE) does your company have ***in New York State***? Your best estimate is fine. *[PROGRAMMER: set range from 0 to 10,000]*
7. What was your company's total revenue from CHP systems in 2015? Your best estimate is fine.

1. Provide Response
2. Do Not Wish to Provide

8. Approximately how many CHP installations did your company complete in 2015? This includes all CHP systems that your company installed or assisted in installing that became operational during 2015. Your best estimate is fine.

   Provide Response [PROGRAMMER: set range from 1 to 10,000]

9. Does your company sell or install one or more CHP systems that are included in NYSERDA's "Combined Heat and Power Catalog?"

   1. Yes
   2. No [SKIP TO Q11]
   3. Don't Know [SKIP TO Q11]

10. ***[Ask if Q9=1]*** We would like to learn about the CHP installations your company completed in 2015 ***in New York State specifically***. This includes all CHP systems that your company installed or assisted in installing that became operational during 2015.

Using the table below, please indicate the following: (a) the total number of CHP projects your firm completed in New York State in 2015, (b) the total aggregate capacity (in kW) for those completed projects, and (c) the estimated aggregate cost for those projects. Please provide separate estimates for CHP systems listed in the NYSERDA CHP Catalog, and all other (non-NYSERDA Catalog) CHP systems. As a reminder, this information will be kept confidential and will not be shared with NYSERDA except in summary form. Your best estimates are fine.

CHP SYSTEM TYPE	(A) # OF CHP PROJECTS COMPLETED IN NY STATE IN 2015	(B) AGGREGATE KW OF CHP PROJECTS COMPLETED IN NY STATE IN 2015	(C) AGGREGATE ESTIMATED COST OF CHP PROJECTS IN NY STATE IN 2015
NYSERDA Catalog Systems			
Non-NYSERDA Catalog Systems			

11. ***[Ask if Q9=2 or if Q9=97]*** We would like to learn about the CHP installations your company completed in 2015 ***in New York State specifically***. This includes all CHP systems that your company installed or assisted in installing in 2015 that became operational during 2015.

Using the table below, please indicate the following: (a) the total number of CHP projects your firm completed in New York State in 2015, (b) the total aggregate capacity (in kW) for those completed projects, and (c) the estimated aggregate cost for those projects. As a reminder, this information will be kept confidential and will not be shared with NYSERDA except in summary form. Your best estimates are fine.

(A) # OF CHP PROJECTS IN NY STATE IN 2015	(B) KW OF CHP PROJECTS IN NY STATE IN 2015	(C) TOTAL COST TO FINAL CUSTOMER OF CHP PROJECTS IN NY STATE IN 2015

12. Thinking about all of the projects where your CHP systems were installed **in New York State in 2015**, please select each of the different building types for which your company completed CHP installation projects.

    1. Multi-family Residence

2. Educational Facility
3. Restaurants
4. Hotels
5. Hospitals/Healthcare
6. Assisted Living/Nursing Homes
7. Office Buildings
8. Other Building Type #1
9. Other Building Type #2
10. Other Building Type #3

13. For each of the building types where your CHP systems were installed **in New York State in 2015**, please indicate (a) the total number of CHP projects your firm completed in New York State in 2015, and (b) the total aggregate capacity (in kW) for those projects. Your best estimates are fine. If you do not have the information requested for one or more building type, mark the check box in column (c).

NO.	BUILDING TYPE	(A) # OF CHP PROJECTS IN NY STATE	(B) KW OF CHP PROJECTS IN NY STATE	(C) I DON'T HAVE THIS INFORMATION
(i)	Multi-family Residence			□
(ii)	Educational Facility			□
(iii)	Restaurants			□
(iv)	Hotels			□
(v)	Hospitals/Healthcare			□
(vi)	Assisted Living/Nursing Homes			□
(vii)	Office Buildings			□
(viii)	Unknown			
(ix)	Other Building Type 1 (insert building type verbatim)			□
(x)	Other Building Type 2 (insert building type verbatim)			□
(xi)	Other Building Type 3 (insert building type verbatim)			□

14. Has your company developed and installed any modular CHP systems, other than systems included in the NYSERDA CHP Catalog? For these purposes, "modular" CHP systems are standardized, pre-packaged systems that are not customized for specific projects.
    1. Yes
    2. No [SKIP TO Q16]
15. ***[ASK If Q14=1]*** Please identify the number of projects and capacity (in kW) of modular CHP systems, other than systems included in the NYSERDA CHP Catalog, that your company installed in 2015. Include separate estimates for CHP projects installed a) in New York State, and b) outside of New York State.

LOCATION	(A) # OF CHP PROJECTS	(B) KW OF CHP PROJECTS
In New York State		
Outside New York State		

Number of Installations by Target Market

16. Now we would like to learn about **all** of the CHP installations your company has ever completed in New York State, including those done before 2015.

Using each of the following building types, please indicate (a) the total number of CHP projects your firm has completed in New York, and (b) the total aggregate capacity (in kW) for those completed projects. Please exclude any projects that, to the best of your knowledge, are no longer operational. If there any other building type(s) that represented a major part of your company's CHP business in New York State, please identify the building types and provide information on them as well. If you do not have the information requested for one or more building type, mark the check box in column (c).

NO.	BUILDING TYPE	(A) # OF CHP PROJECTS IN NY STATE UP THROUGH 2015	(B) KW OF CHP PROJECTS IN NY STATE UP THROUGH 2015	(C) I DON'T HAVE THIS INFORMATION
(i)	Multi-family Residence			□
(ii)	Educational Facility			□
(iii)	Restaurants			□
(iv)	Hotels			□
(v)	Hospitals/Healthcare			□
(vi)	Assisted Living/Nursing Homes			□
(vii)	Office Buildings			□
(viii)	Other 1 (specify building type)			□
(ix)	Other 2 (specify building type)			□
(x)	Other 3 (specify building type)			□

Balance-of-System Cost Characterization

[TRANSITION TEXT: "The next few questions ask about *Balance-of-system costs* (sometimes referred to as *soft costs*). These costs include all non-equipment costs associated with installing a CHP system, including architectural, engineering, financing, and legal fees, and other pre- and post-construction expenses. The table below identifies common components of CHP balance-of-system costs."]

ITEM NO.	BALANCE-OF-SYSTEM COST COMPONENT	DESCRIPTION
1	Engineering	Cost of designing the system and integrating it with electrical and mechanical systems
2	Site preparation	Cost to prepare the site where CHP system will be installed (e.g. concrete flooring)
3	Rigging and coordination	Cost of items such as crane rental and use, insurance etc. associated with moving large CHP systems
4	Installation labor/materials	Labor cost for the civil, mechanical, and electrical work and cost of materials such as ductwork, piping, and wiring
5	Project and construction management	General contractor markup and bonding, and performance guarantees
6	Permitting fees	Fees related to procuring required permits
7	Permitting labor	Labor related to procuring required permits
8	Interconnection fees	Cost of interconnection and paralleling. For larger systems, this reflects the cost of paralleling a synchronous generator. For smaller systems, this may be included in the cost of equipment
9	Interconnection labor	Labor associated with interconnection
10	Project Contingency	Reserve for unexpected expenses
11	Financing	Cost, interest, and other charges involved in borrowing the money to purchase the system

17. Are the categories and definitions shown here sufficiently close to how you classify balance-of-system costs that you can answer questions about your costs using these categories?

    1. Yes [SKIP TO Q20]
    2. No

18. ***[ASK if Q17=2]*** Are there any categories of balance-of-system costs you would remove?

    1. Yes
    2. No [SKIP TO Q19]

18a. [Ask if Q18=1] If yes, which?

19. ***[Ask if Q17=2]*** Are there any additional categories of balance-of-system costs you would add?

    1. Yes
    2. No [SKIP TO Q20]

19a. [Ask if Q19=1] If yes, what are they?

20. Are some of these balance-of-system costs incurred only in certain projects? This could include costs incurred only in certain building types; geographic locations; or according to other project characteristics.

    1. Yes
    2. No

21. ***[Ask if Q20=1]*** Using the table below, identify the circumstances under which each category of costs is incurred. Mark each category of costs that your company incurs only in certain projects.

ITEM NO.	BALANCE-OF-SYSTEM COST COMPONENT	INCURRED IN ALL PROJECTS	INCURRED ONLY IN CERTAIN PROJECTS	PROJECT CHARACTERISTICS WHERE COSTS ARE INCURRED
1	Engineering	□	□	
2	Site preparation	□	□	
3	Rigging and coordination	□	□	
4	Installation labor/materials	□	□	
5	Project and construction management	□	□	
6	Permitting fees	□	□	
7	Permitting labor	□	□	
8	Interconnection fees	□	□	
9	Interconnection labor	□	□	
10	Project Contingency	□	□	
11	Financing	□	□	

Balance-of-System Cost Quantification

22. ***[Ask if Q9=1]*** Thinking about the CHP systems installed by your company in New York State in 2015, what percentage of the total project costs would you estimate were balance-of-system costs *for a typical CHP system included in the NYSERDA CHP Catalog*? *[PROGRAMMER: set range as 0-100%]*

    1. Provide Answer
    2. Don't Know

23. ***[Ask if Q9=1]*** Thinking about the CHP systems installed by your company in New York State in 2015, what percentage of the total project costs would you estimate were balance-of-system costs *for a typical CHP system NOT included in the NYSERDA CHP Catalog*? *[PROGRAMMER: set range as 0-100%]*

    1. Provide Answer
    2. Don't Know

24. ***[ASK if Q9=1]*** Using the table below, please rank the **five** largest balance-of-system costs that contribute the most to the overall cost of a typical CHP system installed by your company in New York State in 2015, with 1 being the largest contributor to the overall cost and 5 indicating the fifth largest contributor to the overall cost. *[PROGRAMMER: ALLOW ONLY RANKING OF 1 to 5]*

ITEM NO.	CHP COST COMPONENT
1	Engineering
2	Site preparation
3	Rigging and coordination
4	Installation labor/materials
5	Project and construction management
6	Permitting fees
7	Permitting labor
8	interconnection fees
9	Interconnection labor
10	Project Contingency
11	Financing

25. **[IF Q24 ANSWERED]** For each of the cost categories you ranked, please estimate the percentage of the total balance-of-system costs that each component contributes for a typical NYSERDA Catalog System and separately for a typical non-NYSERDA Catalog System. Please note that the percentages do not need to add to 100%.*[PROGRAMMER: set range as 0-100%]*

ITEM NO.	CHP COST COMPONENT	TYPICAL NYSERDA CATALOG SYSTEMS	TYPICAL NON-NYSERDA CATALOG SYSTEMS
1	Engineering		
2	Site preparation		
3	Rigging and coordination		
4	Installation labor/materials		
5	Project and construction management		
6	Permitting fees		
7	Permitting labor		
8	interconnection fees		
9	Interconnection labor		
10	Project Contingency		
11	Financing		

26. ***[Ask if Q9=1]*** NYSERDA is interested in understanding permitting costs specifically. The following table is intended to isolate costs associated with permitting, including all permits required for a typical CHP project. Using the table below, please estimate the *average cost for a typical CHP project* associated with permitting and inspection labor, and permitting fees. Your best estimates are fine.

COST CATEGORY	AVERAGE COST PER SYSTEM ($) FOR:	
	TYPICAL NYSERDA CATALOG SYSTEMS	TYPICAL NON-NYSERDA CATALOG SYSTEMS
Permitting and Inspection Labor		
Permitting Fees		

27. ***[Ask if Q9=2 or if Q9=97]*** Thinking about the CHP systems installed by your company in New York State in 2015, what percentage of the total project costs would you estimate were balance-of-system costs for a typical CHP system?

1. Provide Answer
2. Don't Know

28. ***[Ask if Q9=2 or if Q9=97]*** Using the table below, please rank the **five** largest balance-of-system costs that contribute the most to the overall cost of a typical CHP system installed by your company in New York State in 2015, with 1 being the largest contributor to the overall cost and 5 indicating the fifth largest contributor to the overall cost. *[PROGRAMMER: ALLOW ONLY RANKING OF 1 to 5]*

ITEM NO.	CHP COST COMPONENT
1	Engineering
2	Site preparation
3	Rigging and coordination
4	Installation labor/materials
5	Project and construction management
6	Permitting fees
7	Permitting labor
8	interconnection fees
9	Interconnection labor
10	Project Contingency
11	Financing

29. **[IF Q28 ANSWERED]** For each of the cost categories you ranked, please estimate the percentage of the total balance-of-system costs that each component contributes for a typical system. Please note that the percentages do not need to add to 100%.*[PROGRAMMER: set range as 0-100%]*

ITEM NO.	CHP COST COMPONENT	PERCENTAGE OF TOTAL BALANCE-OF-SYSTEM COSTS
1	Engineering	
2	Site preparation	
3	Rigging and coordination	
4	Installation labor/materials	
5	Project and construction management	
6	Permitting fees	
7	Permitting labor	
8	interconnection fees	
9	Interconnection labor	
10	Project Contingency	
11	Financing	

30. ***[Ask if Q9=2 or if Q9=97]*** NYSERDA is interested in understanding permitting costs specifically. The following tables are intended to isolate costs associated with permitting, including all permits required for a typical CHP project. Using the tables below, please estimate the *average cost for a typical CHP project* associated with permitting and inspection labor, and permitting fees for each region. Your best estimates are fine.

New York City and Westchester County

COST CATEGORY	AVERAGE COST PER SYSTEM ($)
Permitting and Inspection Labor	
Permitting Fees	

The Rest of New York State (excluding New York City and Westchester County)

COST CATEGORY	AVERAGE COST PER SYSTEM ($)
Permitting and Inspection Labor	
Permitting Fees	

31. ***[Ask if Q9=1]*** For a typical project in New York State in 2015 *included in the NYSERDA CHP Catalog*, how many days did you spend on average waiting for permit approval, such that you were unable to perform other work on the project? *[PROGRAMMER: set range from 0 to 1,000]*

32. ***[Ask if Q9=1]*** For a typical project in New York State in 2015 that was <u>NOT</u> *included in the NYSERDA CHP Catalog*, how many days did you spend on average waiting for permit approval, such that you were unable to perform other work on the project? *[PROGRAMMER: set range from 0 to 1,000]*

33. ***[Ask if Q9=2 or if Q9=97]*** For a typical project in New York State in 2015, how many days did you spend on average waiting for permit approval, such that you were unable to perform other work on the project? *[PROGRAMMER: set range from 0 to 1,000]*

34. ***[Ask if Q9=1]*** NYSERDA requires that vendors offer a five-year warranty on CHP systems in order to receive an incentive payment. For a typical project in New York State in 2015 *included in the NYSERDA CHP Catalog*, what percentage of the total system costs did you set aside or expect to incur for warranty/maintenance for a typical CHP system over this five year period? *[PROGRAMMER: set range from 0 to 100%]*

35. ***[Ask if Q9=1]*** For a typical project in New York State in 2015 *that is <u>NOT</u> included in the NYSERDA CHP Catalog*, what percentage of the total system costs did you set aside or expect to incur for warranty/maintenance for a typical CHP system over this five year period? *[PROGRAMMER: set range from 0 to 100%]*

36. ***[Ask if Q9=2 or if Q9=97]*** NYSERDA requires that vendors offer a five-year warranty on CHP systems in order to receive an incentive payment. For a typical project in New York State in 2015, what percentage of the total system costs did you set aside or expect to incur for warranty/maintenance for a typical CHP system over this five year period? *[PROGRAMMER: set range from 0 to 100%]*

Other Factors Influencing CHP Market Adoption

37. Have you completed any CHP projects during the past three years that were done as part of a larger real estate transaction, such as a purchase or major refinancing of an entire building/property?

    1. Yes
    2. No [SKIP TO Q39]

38. ***[Ask if Q37=1]*** Are you willing to provide the name and contact information of the building owner? We would like to get in touch with them to discuss the relationship between real estate transactions and CHP financing to explore potential opportunities for lowering financing-related barriers to CHP adoption.

    1. Yes [If selected, provide open-end box for name, box for phone, box for e-mail]
    2. No

39. Have you completed any CHP projects during the past three years that were done as part of a larger capital upgrade project?

1. Yes
2. No

40. ***[Ask if Q39=1]*** Are you willing to provide the name and contact information of the building owner? We would like to get in touch with them to discuss the relationship between such transactions and CHP financing to explore potential opportunities for lowering financing-related barriers to CHP adoption.
    1. Yes [If selected, provide open-end box for name, box for phone, box for e-mail]
    2. No

Other

[TRANSITION TEXT: "You are almost finished! Thank you for your time.]

41. Based on your experience, do you have any suggestions on how NYSERDA could facilitate more widespread adoption of CHP?
42. Can we contact you again if we need clarification on any of the questions we asked today?
    1. Yes
    2. No [SKIP TO Q44]
43. ***[Ask if Q42=1]*** Please provide the following information. We will not use your contact information for any other purpose or share it with any other organizations.
    a. Your name
    b Your job title
    c Your email address
44. ***[Ask if Q42=2]*** For validation purposes only, please provide the following information. This information is voluntary and will not be shared with NYSERDA staff.
    a. Your name
    b. Your job title
    c Your email address

[CLOSING: "You have completed the survey. Thank you for your time and participation!"]